by other substructures. The potential clinical benefits still need to be demonstrated in expanded cohorts, with prolonged life-long follow-up.

**PO-0850**

**Interplay effect quantification of PBS lung tumour proton therapy with various fractionation schemes**

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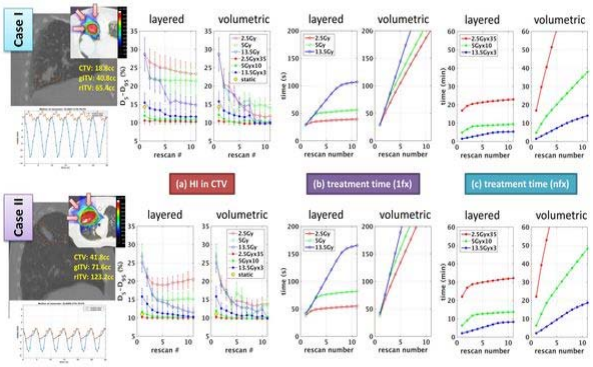
**Purpose or Objective:** This study aims to investigate how much fractionation, and the different delivery dynamics of higher dose-per-fraction deliveries, can influence the impact of interplay effects for PBS-based lung tumour treatments.

**Material and Methods:** For two example lung tumour cases (I and II), three-field 3D plans were calculated on a patient specific range-adapted ITV (rITV) using a spot spacing of 4mm orthogonal to the beam directions. 4D dose calculations were performed, simulating three different fractionation treatments with schemes of (A)2.5Gyx35fx, (B)5Gyx10fx and (C)13.5Gyx3fx, based on machine and delivery parameters of the Varian ProBeam system (lateral scanning speed of 5/20 mm/ms and energy switching time of 700 ms with layer-wise optimized dose rates). 1x- to 10x- layered and volumetric rescanning was simulated to mitigate residual motion effects. The final dose distributions for fractioned treatments were obtained by superposition and normalization of the 4D dose distributions of each field and each fraction with random starting phases sampled from 4DCT (10 different phases with 100 random starts). We used homogeneity index (HI:D5-D95) in the CTV to quantify the resultant 4D dose distributions within the target, while for the normal lung (both lungs minus CTV), V20, mean lung dose (MLD) and D2 were compared.

**Results:** For single fraction only delivery (shown by error bars with hollow markers in figure a), the normalized HIs are similar for the different fraction doses for both patients, with HI being typically 14/15% higher than the static for case I and II respectively. For the full treatments (solid markers), the normalized HIs of plans under scheme A and B are equal or better than for the static plan, with only ±1.2% variations as a function of starting phase. In addition, whereas for scheme C, HI is 2.5±2.6/4.8±2.3% (Case I/II) higher than the static case, this also reaches comparable homogeneity as the static case once combined with moderate rescanning (<5x). Variability is also reduced to within 1%, independent of the rescanning technique used. Concerning treatment time, for single fractions, nearly no difference can be seen among the different schemes when no rescanning is applied, due to the layer-wise optimized dose rate used by the ProBeam system. For 5x LS or VS, treatment time is increased by 100% and 37% respectively for scheme C in comparison to scheme A, although the absolute treatment time for LS is always less than half that of VS for all schemes. For the whole treatment, more than 75% reduction of time cost can be obtained once fractionation scheme (C) is used.




**Conclusion:** For PBS-based lung tumour proton therapy, fractionation can lead to an improved target homogeneity, and variability as a function of starting phase is only obvious when large fraction doses are used and can be reduced with moderate (<5x) rescanning is applied.

**PO-0851**

**Development of a postoperative image-based treatment planning system for breast IOERT**

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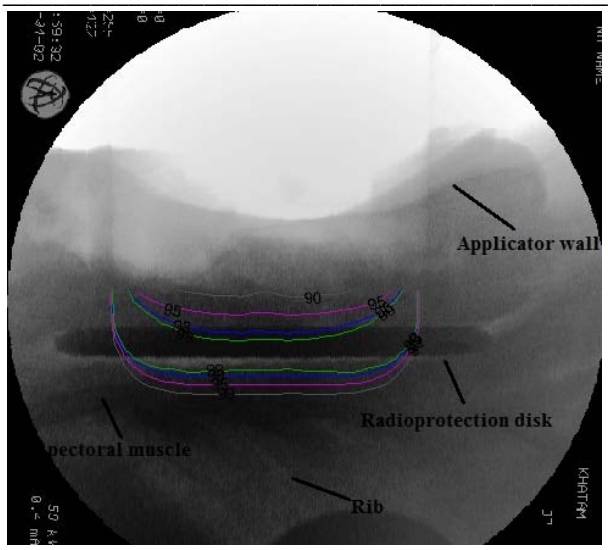
**Purpose or Objective:** One of the major limitations of IOERT is the lack of a postoperative image based treatment planning, in order to optimize the radiotherapy procedure. The aim of this study is to develop and introduce a postoperative image based treatment planning system for breast cancer IOERT.

**Material and Methods;** to obtain a postoperative image based treatment planning software, it is necessary to have a postoperative image which includes the anatomical modifications of the tumor bed after the surgery. To this end, a C-arm fluoroscopy system (Zeihm Vision-8000) was employed to obtain a series of 2D images which include the tumor bed together with the IORT applicator and protection disk.In addition to the postoperative images, it is mandatory to have the complete isodose distributions for different combinations of applicator size/energy. To obtain this data, Monte Carlo simulation was employed. The LIAC IORT accelerator was simulated by MCNPX code and then, isodose distributions were extracted using mesh tally inside a water phantom. To develop a graphical treatment planning software, a graphical user interface (GUI) was prepared by an in house program written with MATLAB. At first, the postoperative image is imported to the program. Then, the corresponding isodose distribution file is loaded to the program. Then, the user will specify the applicator edge and program registers the isodose curves to the postoperative image. In order to evaluate the performance accuracy of the implemented postoperative image based treatment plans and delivered dose to the patient, in vivo dosimetry was used. To this end, the delivered dose to the surface of tumor bed was measured by Gafchromic EBT2 film.

**Results:** The result of intraopertaive imaging and corresponding treatment planning is shown in Fig. 1.




As it can be seen, the developed treatment planning system is able to clearly show the variations of isodose levels at the site of tumor bed. Therefore, treatment team can precisely determine the interested isodose level for the dose prescription.The results of in vivo dosimetry at the surface of tumor bed showed there is no meaningful difference between the measured and expected dose at the surface of tumor bed (P-value=0.92).

**Conclusion:** The feasibility of intraoperative imaging and development of a postoperative image based treatment planning system during breast cancer IOERT was investigated in this study. The results of in vivo dosimetry confirm the validity of the developed treatment planning system for clinical applications.

**PO-0852**

**The dose in marrow of iliac plates during radiotherapy of cervical and endometrial cancer**

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**Purpose or Objective:** To compare the differences between average doses cumulated in the marrow of iliac plates (PBM), obtained for five different radiotherapy strategies of cervical and endometrial cancer.

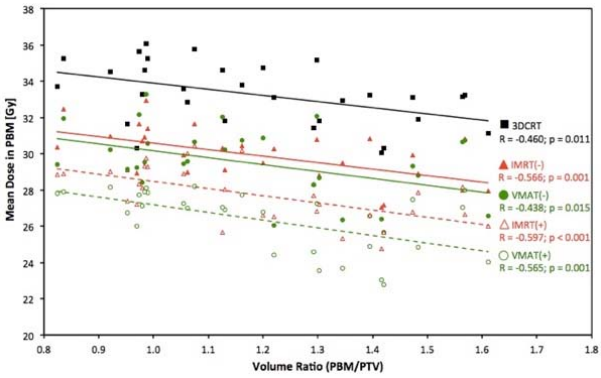
**Material and Methods:** A total of 150 treatment plans were calculated retrospectively for 30 patients with cervical and endometrial cancer.
For each case, 3 different dose delivery techniques were used. It were respectively: (i) 4-field, X15MV, 3DCRT; (ii) 7-field, X6MV, IMRT; and (iii) 2-arc, X6MV, VMAT. Two strategies were used during preparation of the IMRT and VMAT plans. The first take into account (+) PBM during optimization of the dose distribution and the second, do not take it into account (-).
All plans were normalized on the median dose in PTV. The same calculation algorithm (AAA) was used for calculation of the dose for each of plan. The total dose was 50.4 Gy (1.8 Gy in 28 fractions).
Average doses cumulated in PTV, PBM, bladder, rectum, bowels and femoral heads obtained from the evaluated plans were compared. In addition, the doses accumulated in PBM were analyzed in the light of the volume of PTV and/or PBM.
The statistical analysis were performed by Friedman ANOVA with Nemenyi's procedures used as post-hoc tests. In order to find the relationship between doses in PBM and volume of PTV and/or PBM, the Spearman correlation was used. All tests were performed on the significance level equal to 0.05.

**Results:** Table 1 shows the result of the comparison of the average dose in the light of the generated plans.

| Technique | PTV | PBM | Bladder | Rectum | Bowels | FHR | FHL |
|---|---|---|---|---|---|---|---|
| | Average Dose (Standard Deviation) [Gy] | | | | | | |
| 3DCRT | 50.4 (0.1) | 33.3 (1.7) | 49.9 (0.4) | 47.7 (1.6) | 37.6 (2.4) | 38.2 (1.2) | 38.3 (2.8) |
| IMRT(-) | 50.4 (0.1) | 29.9 (1.5) | 35.4 (1.7) | 36.2 (3.0) | 32.6 (1.3) | 25.4 (1.3) | 27.7 (1.6) |
| VMAT(-) | 50.4 (0.1) | 29.4 (2.0) | 34.6 (2.4) | 35.7 (2.6) | 33.2 (1.1) | 26.3 (1.8) | 28.7 (1.7) |
| IMRT(+) | 50.5 (0.1) | 27.7 (1.5) | 35.5 (2.9) | 36.3 (2.8) | 32.6 (1.3) | 23.9 (1.4) | 24.4 (2.2) |
| VMAT(+) | 50.4 (0.1) | 26.4 (1.7) | 34.6 (2.8) | 35.7 (2.9) | 32.9 (1.1) | 24.1 (1.2) | 25.0 (2.0) |
| Technique | Similarity/Dissimilarity of the results | | | | | | |
| | p = 0.998 | p < 0.001 | p < 0.001 | p < 0.001 | p < 0.001 | p < 0.007 | p < 0.011 |
| 3DCRT | A | A | A | A | A | A | A |
| IMRT(-) | A | B | B | B | B | B | B |
| VMAT(-) | A | B | B | B | B | B | B |
| IMRT(+) | A | C | B | B | B | C | C |
| VMAT(+) | A | C | B | B | B | C | C |

*PTV - Planning Target Volume; PBM - The bone marrow in the iliac plates; FHR - right femoral head; FHL - left femoral head*

The average dose in PTV for evaluated plans was similar. The worst doses in organs at risk were obtained for 3DCRT. Using the PBM during optimization of IMRT and VMAT reduces the average dose in PBM without increasing the doses in bladder, rectum and bowels. Differences between doses in PBM for IMRT and VMAT plans, where PBM was used during optimization, were not statistically significant. The correlation between mean dose in PBM and the volume ratio of PBM and PTV was found for each technique (Figure 1).




**Conclusion:** Using the PBM during optimization of the IMRT and VMAT plans effectively reduces the dose in PBM without increasing the dose in bladder, rectum and bowels. The doses, obtained in PBM for IMRT and VMAT are not statistically different. Decreasing the PBM volume in relation to PTV increases the mean dose in PBM.

**PO-0853**

**Impact of CT modality used for treatment planning of lung SBRT**

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**Purpose or Objective:** The introduction of lung stereotactic body radiation therapy (SBRT) requires images that allow a more precise delineation of the tumor and its movement. The free breathing CT does not contain information on the variable electron density over time. The objective of this study is to analyze the CT mode that provides the best estimation of the tumor movement and the most appropriate image set for the calculation of the dose distribution image.

**Material and Methods:** 10 patients were retrospectively investigated. For each patient, a retrospective 4DCT was acquired using a Brilliance 16-slice scanner. From the 4DCT study, 10 respiratory phases, an average CT and a maximum intensity projection (MIP) were reconstructed. The gross tumor volumes (GTV) were delineated in each image set of the 4DCT using a MIM® 6.4 software. Three internal target volumes (ITV) were obtained, one from the union of GTVs delineated in each phase, another from the average CT and the last from the MIP reconstruction. Special care was taken with the window level selection when contouring. The size of the three ITVs was compared. The planning target volume